# TRUNK – CROWN GROWTH TRADE OFF IN POLLARDED TREES: INFLUENCE ON WOOD PRODUCTION

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## Introduction

Modern agriculture faces many challenges. While the world's demand for food is increasing conventional farming has progressively become a threat to environment and human health (Tilman and Clark 2015). Under this environmental crisis context, agroforestry is viewed as one of the solutions to preserve soils, water table quality and biological diversity while diversifying productions that are less dependent on chemical inputs (Dupraz and Liagre 2008). Introducing trees into cultivated fields may also benefit to the crop (regarding microclimate, pest control, etc.) but mature trees may also compete too strongly for light with the crop. Reducing tree density may reduce this phenomenon but it may also reduce their beneficial impacts on the crops.

Another solution is to pollard the trees. Pollarding is an age-old practice that emerged worldwide from farmers good sense (Thomas 2000; Mansion 2010). It consists of periodically harvesting the tree branches by pruning. It reduces tree shade on crops, provides habitats for an increased biological diversity and allows a regular harvest of wood. However, these practices have been poorly investigated scientifically. In particular, only few studies can be found regarding the impact of pollarding on the physiological responses of the trees to these disturbance or more specifically on wood production (Ferrini 2006).

On the one hand, the hypothesis of functional equilibrium within a plant (Poorter and Nagel 2000) predicts that pruned plants exhibit a strong re-growth of the pruned organs. As empirical knowledge also suggests, it is expected that pruned trees exhibit an important vigour in their regrowth period (Ferrini 2006) to restore the functional balance between above- and below-ground plant organs. On the other hand, it has been shown that after pollarding a tree, the secondary growth of its trunk tends to strongly decrease (Bernard et al. 2006; Ferrini 2006). However, the relationship between the increased vigor of branch regrowth and the decreased trunk growth as not been investigated.

In this study, we assessed the past growth of the trunk of pollarded ash trees (*Fraxinus excelsior* L., 1753) in a sylvopastoral region of Western France using dendrochronology. We also established an allometry between tree size, time since the last branch harvest and crown growth. We then used the relationship between trunk and crown growth to propose pollarding scenarios that could optimize wood production.

## Material and methods

### *Study area*

The sampling area is located in an embanked marshlands (called "Marais Poitevin") of Western France (46°30'–46°27' North and 1°30'–1°35' West). This wetland has been traditionally managed as a sylvopastoral area with numerous pollarded trees mostly used to produce firewood or fodder for livestock and to protect drainage channel banks. The most common species in this wetland is ash tree (*Fraxinus excelsior*).

### *Data collection*

We sampled 133 pollarded ash trees in 5 locations within the area. Two (orthogonal) radial wood cores (at 1.30 m high) were extracted from each tree with an increment-borer. The wood cores were dried, stuck on a wooden stick and sanded with successive finer grades of sandpaper until growth rings were clearly visible (P240 to P600 grit) (Schweingruber 1988). Tree ring widths were then measured with a Lintab version 5 measuring system and TSAPWin (4.69e) software.

Crossdating samples is essential to identify missing or extra growth rings (Lebourgeois and Merian 2010). This is usually done by identifying pointer years (i.e. extraordinary low growth

reflecting a severe drought) used to synchronize growth series (Schweingruber et al. 1990). However, as documented by Bernard et al. (2006) and Ferrini (2006), a strong decrease of trunk growth following branch harvest was expected and actually observed in our samples (as well as other microscopic anatomic markers). These markers were used to identify and date branch harvest episodes but also as temporal markers for crossdating trees within each tree hedge (being traditionally all cut at the same moment).
The age of tree crowns were estimated directly with an architectural method (Hallé *et al.*, 1978) for young crowns (up to 6 – 7 years) or measured from extra wood cores taken from the base of a large branch for older crowns. Diameter at the base of all branches were all measured and 46 branches were samples, dried (30 days at 50°C) and weighted to develop an allometry. Crown dry biomass could thus be estimated for every pollarded tree.

*Analysis*

We used linear regressions to model the relationships between tree biomass annual increment (crown and trunk) and tree size (basal area and trunk height) as well as the time since last branch harvest. These models were used to explore various crown harvest scenarios in order to maximize wood production over a 100 years cycle of production. We explored a set of 40 pollarding scenarios. Equally spaced branch harvest episodes (within a given scenario) have been explored through 15 scenarios (harvest intervals from 1 year to 15 years). The other 25 scenarios explored various mixtures of branch harvest interval length (long intervals followed by shorter intervals).

## Results

The models revealed that after branch harvest crown growth is enhanced while trunk growth shrinks. This significant trend reverses with time after branch harvest. It also revealed that tree basal area had a significant impact on trunk and crown biomass growth (**Figure 1**). In particular, crown biomass growth markedly increases with tree basal area.

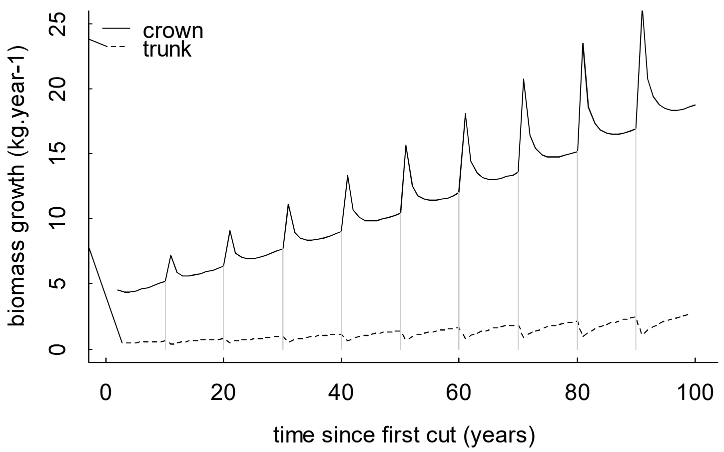


Figure 1: Simulated growth rates of a pollarded ash tree (Initial DBH = 10 cm and trunk height = 2 m). Grey lines reprensent pollarding episodes (every 10 years here).

The set of 40 simulations (**Figure 2** only represents 15 scenarios, other are not shown here)

Figure  revealed that depending on the harvest scenario tested in our analysis, trunk biomass varies between 65.8 kg and 152 kg (coefficient of variation = 18.8%) while total harvested crown biomass varies between 1140.7 kg and 1373 kg (coefficient of variation = 5.4%) after 100 years. The first set of 15 simulations (equally spaced branch harvest, Figure ) shows that trunk biomass after 100 years increases with branch harvest interval length. In the meantime, it shows that crown biomass first decreases and then increases with branch harvest interval length. Other scenarios mixing harvest interval length led to simulate higher branch biomass but no clear trade-off appeared between trunk and branches production (result not shown here).

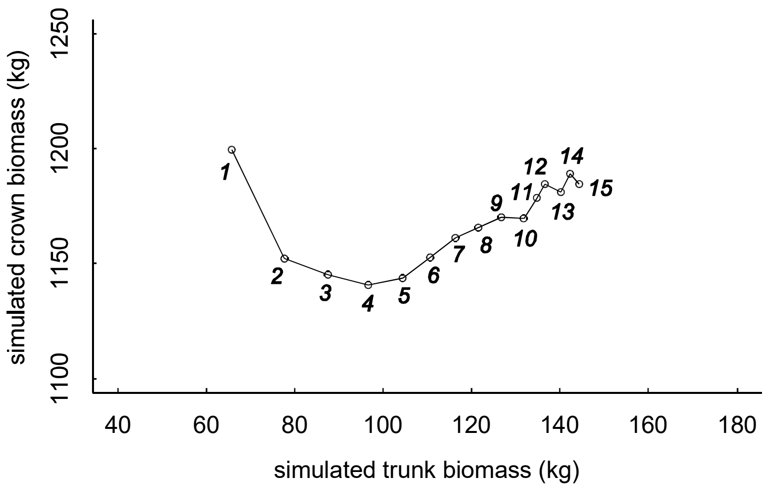


Figure 2: Simulated trunk and crown biomass produced over 100 years under 15 different branch harvest scenarios. Branch harvest intervals are egually spaced within each given scenario. Numbers represent branch harvest interval length (in years) within a given scenario.

**Discussion**

As expected, branches growth is enhanced and trunk growth shrinks after branch harvest. However, we showed that branch production also depended on the trunk size. It appeared that shortening time between branch harvest (that also reduces trunk growth) do not lead to maximize branch production. Increasing branch harvest interval length actually allowed the tree to increase its basal area that in turn increases branch production. As a conclusion, in order to increase biomass production, a compromise needs to be found between long intervals allowing the trunk to get larger and short intervals that increase branch growth rate (given a certain trunk basal area). It appeared that favoring long harvest intervals when the tree is young and shortening these intervals when the tree is larger increases branch production.

Finally, we showed that several combinations of interval lengths between branch harvests could lead to similar trunk biomass but different crown biomass (or the opposite). This flexibility thus gives the possibility to the farmer to adapt its management practices to its current needs (firewood, chipped branched wood) or to the fluctuations of wood markets. In addition, some supplementary clues (not presented here) tend to reflect that in our samples branches may have been harvested either in summer or in winter. A hypothesis to be tested is that while it is common to pollard during winter, farmers may have chosen to pollard during summer to provide fodder for livestock.

Further investigations are also still needed to better understand the tree reaction to such practices, in particular if a tree can withstand short branch harvest intervals on the long term.

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